This segment covers ecological topics, including ecological organization, relationships among physical factors of the biosphere and the organismal adaptations, laws of thermodynamics, and biodiversity.

Student Science Performance

Environmental Science	**Title**
Topic: Ecology The amount of time estimated for this instructional unit is nine weeks for a traditional schedule and 4.5 weeks for a block schedule.	Planet Earth: Ecology

Performance Expectation for GSE:

SEV1. Obtain, evaluate, and communicate information to investigate the flow of energy and cycling of matter within an ecosystem.

a. Develop and use a model to compare and analyze the levels of biological organization including organisms, populations, communities, ecosystems, and biosphere.
b. Develop and use a model based on the Laws of Thermodynamics to predict energy transfers throughout an ecosystem (food chains, food webs, and trophic levels).
c. (Clarification statement: The first and second law of thermodynamics should be used to support the model.)
d. Evaluate claims, evidence, and reasoning of the relationship between the physical factors (e.g., insolation, proximity to coastline, topography) and organismal adaptations within terrestrial biomes.

SEV2. Obtain, evaluate, and communicate information to construct explanations of stability and change in Earth's ecosystems.

c. Construct an argument to predict changes in biomass, biodiversity, and complexity within ecosystems, in terms of ecological succession.
d. Construct an argument to support a claim about the value of biodiversity in ecosystem resilience including keystone, invasive, native, endemic, indicator, and endangered species.

Performance Expectations for Instruction:

Students will keep an environmental science journal to capture information, questions, and/or experiences to create the sustainability plan in the final capstone project.

I can

- obtain, evaluate, and communicate information throughout the instructional segment.
- develop and use a model of the levels of biological organization.
- develop and use a food web to model the laws of thermodynamics to predict energy transfers.
- analyze and interpret data to communicate information to determine the relationship between the physical factors and the organismal adaptations within the major terrestrial biomes.
- use data to construct an explanation of the relationship between insolation and organismal adaptations.
- collect data to support a claim that organismal adaptations are a function of latitude.
- explain entropy in terms of biological processes.
- support a claim of the value of biodiversity in an ecosystem and the role it plays in the resilience of the ecosystem.
- determine the biodiversity in a community and predict how it will change in terms of succession.

Additional notes on student supports

Materials: Students will need to keep an environmental science journal throughout the course. Students will use the information and experiences captured in the environmental science journal to produce the sustainability plan in the final instructional segment. Modeling Laws of Thermodynamics: ● Large bag of dried beans ● Bathroom sized cups ● Five 250mL beakers per group (total of 15) labeled as follows: 　○ Unused sunlight 　○ Growth 　○ Reproduction 　○ Maintain Homeostasis/Immune Defense 　○ Maintain Homeostasis/Daily ● Large plastic container labeled "ENTROPY" (if the sun group runs out of beans, this container can be recycled) ● One 500 mL beaker labeled "TERTIARY CONSUMER"	
Students will continuously obtain, evaluate, and communicate information. This is not a linear process. Students will communicate through writing and discussions to allow for formative assessment. This benefits the teacher, student, and whole group to guide instruction to clarify misconceptions or extend content.	
Engaging Learners	**Phenomenon** Show students a video such as to show our planet as a "spaceship." Incomprehensible: The Scale of The Universe As students view, students should sketch, draw, record how Earth looks from each of the viewpoints. Students could also create a "Know and Wonder" t-chart to record their thoughts (know) and questions (wonder) as they continue to explore "Mothership Earth. The following video segment of the image Earth Rise on Christmas Eve from Apollo 8 mission could be used as an additional or alternative phenomenon to show Earth as the "mothership." If you choose to use this you may want to include a discussion about the historical significance and link this to the movie "Hidden Figures." Earthrise, Then and Now or NASA | LRO Brings "Earthrise" to Everyone Ask: (Students will respond to these questions in the environmental science journal.) ● How would you have felt to be the first human to see Earth from this point of view? ● How is Earth like a spaceship? ● What is the significance of the color of the Earth from space? ● What did you "wonder"? ● How do you as an individual fit into this spaceship model?

In the science journal, students will construct a model of the levels of organization from the biosphere (Earth from space) down to the student as the individual organism by drawing and labeling organisms, populations, communities, ecosystems, and the biosphere. This will serve as a pre-assessment/review as this concept of organization is addressed in 7th grade life science as well as in high school Biology. Teacher may use *Ecological Organization Sort* included in this instructional segment.

Or

Students visit an outdoor area of the school campus, locate a representative of each of the levels of ecological organization either by sketching or by digital images, and place them in the environmental science journal. Students will need to provide a justification of why this image or sketch was used to support the level of organization.

Obtaining

1-Campus Biodiversity Activity

Students will conduct a survey to determine the biodiversity of the school campus and/or an area of interest in the local community by comparing a "natural" area to a low and high cultivation areas. The activity should include a discussion of succession and students should predict how the cultivated areas would change in terms of biomass, biodiversity, and complexity as the area changes towards the climax community. Have students collect data on grid paper. It is more important to count the number of DIFFERENT organisms than to name them. Students can color code and sketch the organism or if technology is available students can photograph each type of organism they find. On the grid paper, the students will estimate the amount of coverage of each species in the sample site.

Several biodiversity activities are found using this link. Biodiversity Activities List with Links

Encourage student choice as some students are more interested in insects, birds, plants, etc. Also, this is an excellent opportunity to teach different methods of to study/monitor populations. Use of the transect or quadrat method will again allow for student choice. These sites should be monitored on a regular basis as students look for natural and human impacts throughout the school year. As students monitor over a period of time student should predict how secondary succession will change this ecosystem in terms of biomass, biodiversity, and complexity.

As an extension: Using local experts, students will identify invasive, endemic, endangered, keystone, and/or indicator species that are in the local ecosystem. This information is used in the capstone project at the end of the course.

	2-Energy Dynamics - Laws of thermodynamics in an ecological system Students will conduct an investigation to model the first two laws of thermodynamics. First Law: Energy cannot be created or destroyed only transformed from one form to another. Second Law: In the path of energy transformation some energy is converted to heat and the entropy increases *Teacher note: Entropy in an ecological system could include the energy required to find food, acquire a mate, mate and produce offspring, protect/defend territory, self or offspring, or digestive process and elimination of wastes.* Teacher may select one of these activities depending upon available resources or may use a similar activity currently available at the local level. There are also a variety of interactive labs and/or computer simulations to have students model the energy flow and laws of thermodynamics. Suitable activities are found by doing a search of ● Brussel sprouts and butterfly larvae ecosystem ● Modeling Energy Flow ● *Modeling Laws of Thermodynamics* ● Water Relay Lesson plan: Energy Conservation in an Ecosystem Teacher Note: This concept goes beyond the construction of a food web, energy pyramid, and definition of the 10% rule that is addressed in the 7th grade life science and high school biology Georgia Standards of Excellence. Students should be able to develop and model the Laws of Thermodynamics to show the flow of energy through the ecosystem.
	Evaluating Students will construct a model of the Laws of Thermodynamics using food web or energy pyramid that is representative of the area surveyed. Students make their model in the science journal.
	Communicating 1-Using the Claim, Evidence, Reasoning writing framework (C-E-R), students will predict how succession will change an ecosystem in terms of biomass, biodiversity, and complexity. 2-Using the Claim, Evidence, Reasoning writing framework (C-E-R), students will explain the laws of thermodynamics to predict the flow of energy in the ecosystem surveyed.

Exploring	Obtaining Students will plan and carry out an investigation to determine how proximity to a body of water impacts the temperature of a biome. *Teacher note:* This should be similar to the activity students may have done in 6th grade earth science to demonstrate the uneven heating of land and water. An example can be found at NASA's Heating Earth's Surfaces: Land Versus Water. 2-Students will carry out an investigation to evaluate evidence of the relationship of insolation, seasons, and organismal adaptations within the terrestrial biome. This activity can be done with probe-ware as well as with analog thermometers. (Be sure to include angles of 22^{o} and 24^{o} as these will be important measures in Segment 2 when investigating the obliquity of the Milankovitch cycle.) DISTANCE AND INCLINATION is a lesson activity from NASA resources; the file can be found by searching for "Distance and Inclination" in TRL. 3-Students will use a world map to graphical represent information for the biomes. The world map should also include the major ocean currents and temperature along with the prevailing wind patterns. These physical factors will enable the students to construct an explanation for the relationship to the adaptations of the organisms in the biome. ***Mapping the Physical Factors*** Handout on Mapping the Physical Factors allows students to map the biomes on a world map. *Teacher Note:* This map will be used and added to in subsequent teaching segments.
	Evaluating Ask: ● How does the unequal heating of land and water impact ocean currents and wind patterns? ● What is the relationship between the angle of insolation and latitude? ● What latitudes do we find the majority of the deserts? ● How is this related to the wind patterns and distance from the oceans? ● What is the relationship between the major ocean currents and the direction of the major wind patterns? ● California and Florida are close to the same latitude. Why are the climates very different? ● Why are there no deserts on the east coast of North America? ● What is the relationship between mountain ranges and the locations of forest and desert biomes?

	Formative Assessment of Student Learning
Explaining Finalizing Model	Obtaining Students obtain information regarding the major terrestrial biomes (deciduous forest, tropical rainforest, desert, savanna, chaparral, temperate grassland, taiga or coniferous forest, and tundra) Students will begin to gather data/information into their journal by using the Biome Research Chart as a template. This should be completed as a jigsaw in which each group is given a major terrestrial biome and then the biome experts return to their home group to report out. Research information including • Adaptations of representative plants and animals • Keystone, endemic, endangered, and bioindicator species • Latitude bands • Average temperature and precipitation (climatographs) • Disruptive events (fire, volcano, tsunami, etc.) • Soil type/nutrients available • Length of growing season/seasonal variation of day/night (function of insolation … latitude) • Proximity to an ocean or major body of water • Food web with emphasis on Laws of Thermodynamics Ask: • How are the plants and animals similar/different in each biome? Characteristics to consider might include size, diversity, modifications to prevent water loss or to endure changes in seasonal or daily temperature changes. • What physical factors are unique to the biome? • How are latitude and angle of insolation important to defining a biome? • How does proximity to a large body of water impact the adaptations of the organisms in the biome? • What is necessary for these organisms to survive and thrive over time? What makes it resilient to change? • How do biomes change with weather events such as storms, drought, etc.? How are the organisms affected? • What human made conditions could change the resilience of an ecosystem? Think about construction, pollution, etc. • How does the amount of daylight and dark change with the seasons? Background on Major Terrestrial Biomes *Teacher Note:* Emphasis in this instructional segment should be on the relationships of these physical factors and the adaptations of the organisms within the biomes.

	Using the Biome Research Chart, World Map, and the investigations of the physical factors, students will create a display of their biome with an emphasis on the relationship among the physical factors and the adaptations of the organisms found in that biome. Provide biome groups large pieces of paper or butcher paper to illustrate and label their research of a major biome. Have them include pictures of organisms, abiotic factors, and weather information. **OR** Students can do an electronic presentation using traditional PowerPoint, Prezi, Flipgrid, paper slides projects, or other software. Have students return to their home groups to be the "expert" presenter for the biome. A gallery walk or small group discussion are ways to structure this. Have students evaluate the claims that others have made and leave feedback for them. Allow students to go back and read the feedback left for them and journal their thoughts after conducting their own research, writing and presenting their own claim, and listening to the feedback of others.
	Evaluating Place the terms keystone, endemic, endangered and indicator species on the bulletin board or wall in the classroom/hallway. Students will place an image of the organism and a "hint" to the biome in which it is found (preferably a student creation and not a printed image from the internet) under the appropriate label. Students will explain (orally or in the science journal) why the images is an example of the particular ecological designation.
	Communicating Using the Claim, Evidence, Reasoning writing framework (C-E-R), student should choose a keystone, endemic, endangered or indicator species from their specific biome and write a claim for how that species has adapted to the physical factors within their biome based on evidence from their research. Students should also include why this organism is an example of the ecological species. Students should use reasoning to explain why their evidence supports their claim.
Elaborating Applying Model to Solve a Problems	***Wanted-Invasive or endangered species activity*** Students will design a wanted type poster for an invasive, endangered, keystone, or indicator species of their choice. Students could use those identified in the adaptations portion of the biome research. Format of this activity could be a public service announcement instead of a poster depending up on the choice of the students and the availability of the technology in the classroom.

	OR Students could engage in a debate as to the need to protect or allow species to die out. Many resources are available for this type of debate. There are multiple platforms for this activity as well. Students could conduct a Socratic Seminar, produce a blog, or use technology applications such Padlet or Flipgrid. The Big Question: Should we worry about extinction?
	Evaluating Students will evaluate the sources of information as they prepare the wanted poster, public service announcement, Socratic seminar or debate. Students will also evaluate the information from their peers in this task in order to communicate the validity of their claim.
	Communicating Students will gallery walk posters, view/listen to public service announcements and/or participate in the Socratic Seminar or debate.
Evaluation	**Assessment of Student Learning**
	Assessment of student learning should be ongoing throughout the instructional segment. As students record and reflect in the Science Journal, teacher should provide feedback and commentary to guide the student through misconceptions and lack of sufficient evidence or poor-quality sources. Frequent mini checks can be utilized to monitor student understanding at the element level of the standard. The Claim-Evidence-Reasoning writing pieces should be given specific feedback and commentary with opportunities to revise. These writing sample could be kept in a folder for students to see the progress they have made as they write throughout the course.
SEP, CCC, DCI	*Science Essentials*
Science and Engineering Practices	● Developing and using models ● Constructing explanations ● Asking questions ● Engaging in argument from evidence
Crosscutting Concepts	● Systems and System models ● Stability and Change ● Structure and function
Disciplinary Core Ideas	● Structure and Function ● Independent Relationships in Ecosystems ● Ecosystem Dynamics, Functioning, and Resilience ● Cycles of Matter and Energy Transfer in Ecosystems ● Conservation of energy and energy transfer ● Adaptation ● The Roles of Water in Earth's Surface Processes ● Biodiversity and humans

Additional Supports for struggling learners:		
General supports for the following categories:		
Reading: 1. Provide reading support by reading aloud or doing partner reads 2. The teacher should read and annotate a text with students so that the students may see what the teacher thinks as they read.	Writing: 1. The teacher can provide a sentence starter for the students. 2. The teacher can give students an audience to write to (i.e. Write a letter to your sibling explaining this topic). 3. The teacher can provide constructive feedback during the writing process to help students understand the expectations.	Math: 1. The teacher should model how to create and read a graph including labeling all the parts of the graph. 2. The teacher should provide graph paper so that students do not have to free hand a graph. Many students will get caught up in the drawing and forget basic graphing concepts. 3. The teacher should provide some graph reading practice for students that have trouble constructing the graph.
Supports for this specific lesson if needed:		

Engage:

1. Students may need to see the video more than once or have the video paused to help students keep up with how the earth looks.
2. Provide students with a KWL chart to record their knowledge and questions.
3. The teacher should consider using closed captioning or providing students with transcripts for any video that is shown in class.
4. Consider providing students with questions in advance of the video to help students determine what information is the most important.
5. The teacher should consider providing an alternative to writing for students to record answers th the questions. This could be done using technology and allowing students to dictate their answers or record video. Another set of options without using technology it could be done by allowing students to draw their answers, design a play or verbally explain their thoughts.
6. The teacher should consider providing students with a graphic organizer to allow students to organize their thoughts prior to constructing a model of the levels of organization.
7. The teacher should consider providing students with a rubric for anything that is to be graded. This allows students to understand the expectations and feel more confident in their ability to complete the assignment.
8. Use intentional and flexible grouping to group students.
9. The teacher should have clear and consistent guidelines for group work. This is to ensure that students can all contribute and feel safe within their groups.
10. Consider pairing students in so that they can help one another with the biodiversity survey.
11. The teacher should prepare students for any visitors that may come to class. Some students do not handle change very well and are anxious when changes occur in the classroom. Preparing students ahead of changes can lessen anxiety for students.

12. Provide students with verbal, written or drawn instructions that explain the different ways that students could study a population (explicit instructions that show how to use the transect and/or quadrant method). The teacher should consider that multiple formats of directions may make it easier for students to accomplish this task.
13. The teacher should consider providing students with an example of how scientist use the population study methods in the form of a demo or video.
14. The teacher can consider using food webs and energy pyramids to help students activate prior knowledge from Biology and 7th grade about energy transfer. Then the teacher can bring in the laws of thermodynamics.
15. The teacher should consider using a graphic organizer to give students a way to organize their thoughts prior to constructing a model.
16. The teacher should consider providing students with multiple formats to share their knowledge. These formats could include designing a play, written, drawn or verbally explained.

Exploring:

1. The teacher should use intentional and flexible grouping to group students.
2. The teacher should have clear and consistent guidelines for group work. This is to ensure that all students feel comfortable and able to participate in groupwork. It also ensures that all students contribute to the work that the group is doing.
3. The teacher should consider providing students with an organizer to assist students in planning their investigation.
4. The teacher should consider showing students the materials that they can choose from prior to the planning process.
5. The teacher should consider assisting students in the planning process by walking students through the teacher's thought process of planning an investigation. This helps students understand the requirements of planning an investigation and the aim of conducting an investigation.
6. The teacher should be walking around to answer questions, checking in with students and asking questions about the design and investigation process.
7. The teacher can use guiding questions to assist students in getting the measurements that are required for later parts of the lesson.
8. The teacher may need to assist students in reading a map. The teacher should consider a small refresher lesson on map reading. Another option would be to use a formative assessment to determine who needs the review of reading a map to differentiate for student needs.
9. The teacher may need to assist students in mapping physical features by modeling the mapping process and then having students contribute to a class map as they work. This ensures that all students have maps that they can use.
10. The teacher should consider providing students with the questions prior to the discussion. This gives students the opportunity to prepare their answers prior to sharing with the class. This increases student confidence and makes it more likely that students will participate in the discussion.
11. The teacher should have a set of clear and consistent guidelines for class discussions. This will make discussion flow more smoothly and make students feel more comfortable sharing in class which leads to more student participation.

Explaining:

1. The teacher should consider providing students with sources or information about where to find sources about biomes.
2. The teacher should consider modeling how they find resources that are reliable. This gives students insight into what types of information and sites they are looking for to find information that is likely true and believable.

3. The teacher should consider the class and if the jigsaw method is the most effective. This assignment could also be accomplished as a gallery walk and discussion if this suits the student population better.
4. The teacher should consider providing students with a checklist of information they need about each biome to go along with the chart they are filling in.
5. The teacher should use intentional and flexible grouping to group students.
6. The teacher should have clear and consistent guidelines for group work. This ensures that all students are participating, and that each student feels safe to contribute in the group.
7. The teacher should consider providing students with questions in advance of class discussion. This allows students to prepare answers and be more likely to participate in class discussions.
8. The teacher should consider providing students with multiple formats to share their knowledge. These formats could include written, verbally explained, drawings or using technology to make a video.

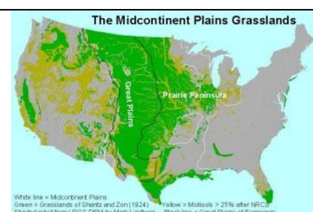
Elaborating:

1. The teacher should attempt to provide choice for as many of the activities as possible. This will encourage students to participate in the activity and make some kind of product to turn in.
2. The teacher should consider providing a rubric for any activity that they are assigning students to give students clear understanding of the expectations of the assignment.
3. If the teacher chooses the debate route, then the teacher should have clear and consistent guidelines for the students to engage in the debate.
4. The teacher should consider providing students with sentence starters for the students to begin their arguments.
5. The teacher should consider having a system in place to ensure that all students have the chance to contribute to the debate.
6. The teacher should have clear and consistent guidelines for group discussions. These guidelines should help students feel more comfortable and be more likely to participate in the discussion.
7. The teacher should consider providing students with a checklist to help students evaluate their resources.
8. Teachers should have clear and consistent guidelines for students to participate in sharing sessions. These guidelines should help students understand what is expected when they are sharing and when they are listening. This should help students feel more comfortable and be more likely to be willing to share.

Evaluating:

1. The teacher should provide students with multiple ways to share their knowledge. These formats could include written, verbally explaining, designing a play, drawing or using technology to make a video.
2. The teacher should provide positive, constructive and clear feedback to help students make improvements on their work.

Organization of Ecology Manipulative

Organism	Individual living thing	
Population	Group of one type of organisms living in the same area	
Community	Different populations living together	
Ecosystem	Community and the nonliving parts of the ecosystem (biotic and abiotic)	
Biome	Places with similar climates and organism	
Biosphere	The parts of Earth that contain all ecosystems	

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Modeling Laws of Thermodynamics in Ecological Systems

In this class activity, students will develop and model the Laws of Thermodynamics to predict energy transformations throughout an ecosystem.

Materials:

- Large bag of dried beans
- Bathroom sized cups
- Five 250mL beakers per group (total of 15) labeled as follows:
    - Unused sunlight
    - Growth
    - Reproduction
    - Maintain Homeostasis/Immune Defense
    - Maintain Homeostasis/Daily
- Large plastic container labeled "ENTROPY" (if the sun group runs out of beans, this container can be recycled)
- One 500 mL beaker labeled "TERTIARY CONSUMER"

Students will be assigned one of three different roles in this activity:

-- sun (10 students)

-- producers (10 students)

-- primary consumers (5 students)

-- secondary consumers (2 students)

The energy itself will be represented by beans.

The time for each trial is 25 minutes. Run the scenario for three trials.

Students will construct a data table in the environmental science notebook.

Though you will only play one role, make sure to read the instructions for all groups in order to analyze the overall results of the lab in your report.

Sun groups:

You will have a large container of beans that represents the large amount of energy released by nuclear fusion of hydrogen atoms into helium atoms. Your goal is to constantly produce groups of 10 beans in a cup (representing packets of light energy called photons) and deliver them only to producer groups. (After all, consumers cannot convert your light energy into biomass energy.)

After you deliver a cup of 10 beans, mark 1 tally on your data recording sheet. This will help us account for how much energy moved throughout the trophic levels during the activity.

Producer groups:

As sun groups deliver a cup filled with 10 beans, empty the cup (Make the cup available to the sun groups when they return with another full cup.) in front of a member of the producer group. Each member of the group will work from an individual cup. In order to stay alive as a plant, you need to spend each group of 10 beans the following way:

1) Unused sunlight (2 beans) – Plants cannot absorb all the sunlight energy that comes to them.
2) Growth (1 bean) – Plants build up their bodies and store the energy in molecules as biomass.
3) Reproduction (2 beans) – Plants produce offspring.
4) Maintaining homeostasis (immune defense) (2 beans) – Plants isolate disease-causing viruses, bacteria, and fungi, preventing them from infecting too many cells within the plant.
5) Maintaining homeostasis (daily maintenance) (3 beans) – Plants need to open / close leaf pores called stomata, repair damaged components, and deliver sugar all around the plant.

Continue to divide the cups of 10 beans as shown above until you have 20 beans in the growth cup. This represents a time when enough biomass exists in plants as a useful food source for primary consumers. First, record the number of beans in each type of cup in your data recording sheet, then deliver ONLY the growth cup of 10 beans to a member of the secondary consumer group. The other cups represent energy that has been transformed to heat through various life processes – so take all of these cups to the “Entropy” bin and dump them in there.

Primary Consumer groups:

As producer group members deliver a cup filled with 20 beans, empty the cup. (Make the cup available to the producer groups when they return with another full cup.) In order to stay alive as an herbivore, you need to spend each group of 20 beans the following way:

1) Unused digestion (feces) (4 beans) – Animals cannot use of all the food energy they consume.
2) Growth (2 bean) – Animals build up their bodies and store the energy in molecules as biomass.
3) Reproduction (4 beans) – Animals produce offspring.

4) Maintaining homeostasis (immune defense) (4 beans) – Animals deter / destroy viruses, bacteria, protist, fungal, and animal pathogens.
5) Maintaining homeostasis (daily maintenance) (6 beans) – Animals move around, digest food and eliminate wastes, repair damaged components, etc.

Continue to divide the cups of 10 beans as shown above until you have 30 beans in the growth cup. This represents a time when enough biomass exists in primary consumers to be a useful food source for secondary consumers. First, record the number of beans in each type of cup in your data recording sheet, then deliver ONLY the growth cup of 30 beans to a member of the carnivore group. The other cups represent energy that has been transformed to heat through various life processes – so take all of these cups to the "Entropy" bin and dump them in there.

Secondary Consumer groups:

As primary consumer group members deliver a cup filled with 30 beans, empty the cup. (Make the cup available to the producer groups when they return with another full cup) In order to stay alive as an herbivore, you need to spend each group of 30 beans the following way:

6) Unused digestion (feces) (6 beans) – Animals cannot use of all the food energy they consume.
7) Growth (3 bean) – Animals build up their bodies and store the energy in molecules as biomass.
8) Reproduction (6 beans) – Animals produce offspring.
9) Maintaining homeostasis (immune defense) (6 beans) – Animals deter / destroy viruses, bacteria, protist, fungal, and animal pathogens.
10) Maintaining homeostasis (daily maintenance) (9 beans) – Animals move around, digest food and eliminate wastes, repair damaged components, etc.

Continue to divide the cups of 30 beans as shown above until you have 40 beans in the growth cup. This represents a time when enough biomass exists in plants to be a useful food source for tertiary consumers. First, record the number of beans in each type of cup in your data recording sheet, then deliver ONLY the growth cup of 40 beans to the tertiary consumer beaker. The other cups represent energy that has been transformed to heat through various life processes – so take all of these cups to the "Entropy" bin and dump them in there.

Laws of Thermodynamics simulation questions

To be completed in the environmental science journal

1. Collect the class data for each trophic level and construct a graph.
2. Calculate the amount of energy that was available to each subsequent trophic level. Be sure to include this value for each trophic level in your model.
3. Sketch a model of the energy flow in this simulation. Label the trophic levels.
4. Only energy stored in the form of ________________ is available to organisms at the next trophic level.
5. In this activity, where did "new" energy come from to sustain the community?
6. What type of processes resulted in the conversion of energy into a biologically unusable form?
7. What form of energy is the biologically unusable energy in this model?
8. Using your model and this simulation, explain the

   1st Law of thermodynamics

   2nd Law of thermodynamics

9. Based on all the scenarios, which trophic level will have populations that are the largest in size? What information are you using to justify your answer?
10. How might the plant disease affect the population size of the herbivores and carnivores? What evidence did you use to make your conclusion?
11. Usually plant diseases only afflict certain plant species – not the entire producer trophic level.
12. How might the impact of plant disease be different if there is a rich diversity of different plant species versus if there are only a few plant species in a community?
13. How might the optimal plant growth affect the population size of the herbivores and carnivores? What evidence did you use to make your conclusion?
14. Most communities only have 4 or 5 trophic levels, not more. Why aren't there 10 trophic levels? Use the Laws of Thermodynamics to support your claim.

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Mapping the Physical Factors

Evaluating evidence of the relationship between the physical factors and organismal adaptations within terrestrial biomes.

Materials:

- Copy of the World Map
- Page protector (each one will make two … split open and cut apart)
- Colored pencils
- Permanent markers

Draw and label the following oceanic surface currents directly on the map. Use red for the warm currents and blue for cool currents.

- Antarctic Circumpolar
- Benguela
- Brazil
- California
- Canary
- East Australian
- Equatorial (north and south)
- Equatorial countercurrent
- Gulf Stream
- Kuroshio (Japan)
- Mozambique
- North Atlantic Drift
- North Pacific Drift
- Peru (Humbolt)
- West Wind Drift
- West Australian

Draw and label the major mountain ranges directly on the map.

- Appalachians
- Alps
- Andes
- Himalayas
- Rockies
- Urals
- Australian Alps
- Sierra Madres
- Pyrennes

Draw and label the major terrestrial biomes directly on the map. Create a color key for your biomes

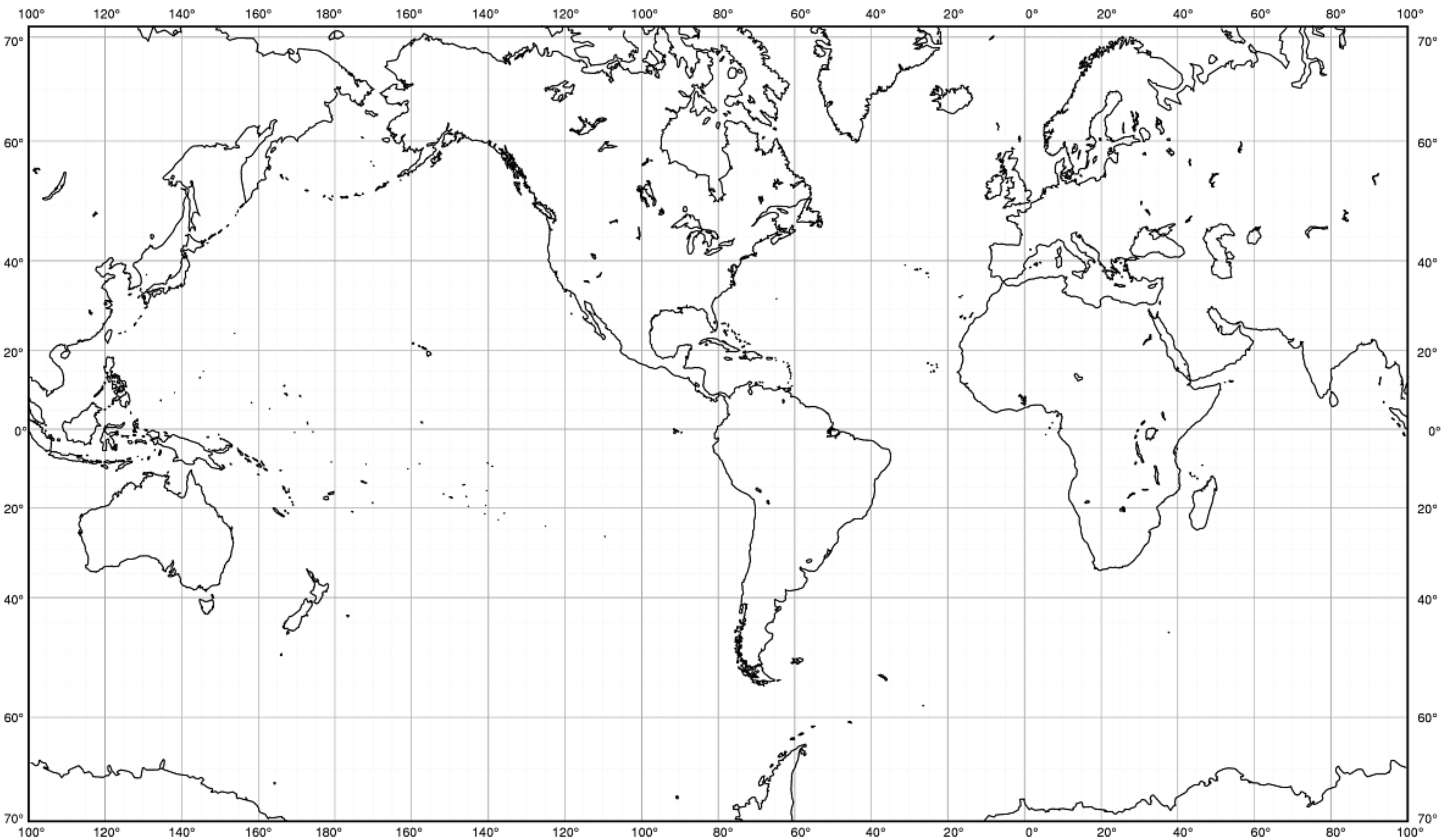
- Boreal forest (taiga, coniferous forest)
- Chaparral
- Desert
- Savanna
- Temperate Deciduous Forest
- Temperate Grassland
- Tropical Rain Forest
- Tundra

Staple the clear page protector to the paper map. Using permanent markers draw and label the prevailing wind patterns in each hemisphere. Include the direction in which the winds move across the Earth.

- Polar Easterlies
- Trade winds
- Westerlies
- Doldrums

Using the evidence you have collected in this activity, construct an explanation of the relationship between the physical factors and the location of the major terrestrial biomes.

World Map



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Terrestrial Biomes: Physical Factors and Organismal Adaptations

Biome Name								
Climatogram (temperature and precipitation)								
Latitude or angle of Insolation (variation in day/night)								
Proximity to Coastline (impact of major ocean currents and prevailing winds)								
Topography (impact of mountain ranges)								
Amount of Biodiversity								

Major Plant Adaptations*									
Major Animal Adaptations*									
Keystone species									
Endangered Species									
Bioindicator species									

*These should be general adaptations, not necessarily adaptations of a specific species (e.g. deciduous plants lose leaves in winter, thick coats of fur for cold weather)

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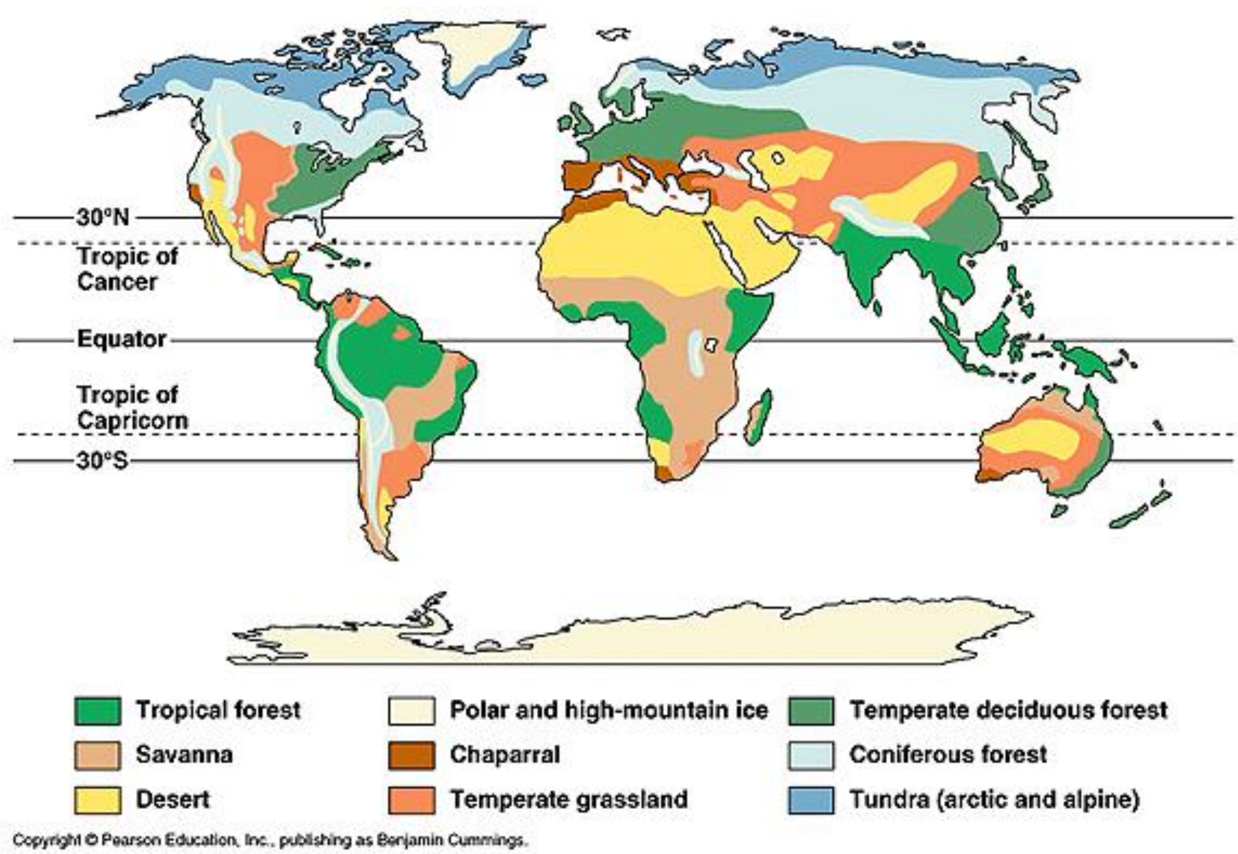
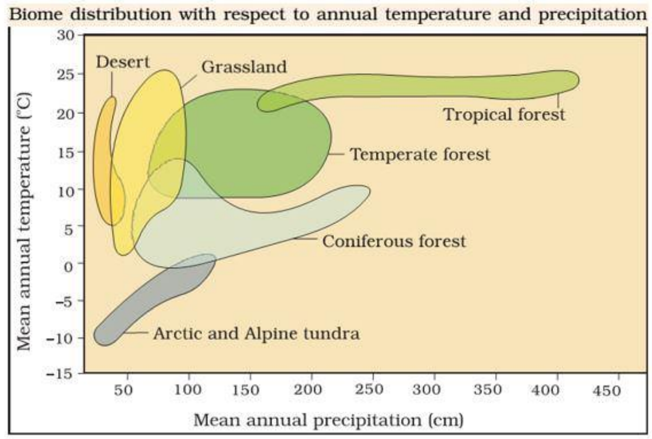
Major Terrestrial Biomes

There are eight major terrestrial **biomes**: tropical rainforests, savannas, subtropical deserts, chaparral, temperate grasslands, temperate forests, boreal forests, and Arctic tundra.



The same biome can occur in different geographic locations with similar climates. Temperature and precipitation, and variations in both, are key abiotic factors that shape the composition of animal and plant communities in terrestrial biomes. Some biomes, such as temperate grasslands and temperate forests, have distinct seasons, with cold weather and hot weather alternating throughout the year. In warm, moist biomes, such as the tropical wet forest, net primary productivity is high, as warm temperatures, abundant water, and a year-round growing season fuel plant growth. Other biomes, such as deserts and tundra, have low primary productivity due to extreme temperatures and a shortage of available water.



This is a visualization that could assist with the development of relationships of physical factors and organismal. The overlap of the biomes in the diagram on the right will help students to see that the boundaries of biomes are fluid and other factors such as altitude, proximity to coastlines, and topography will influence the types of organisms occupying the area.

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Invasive Species or Endangered Species Project

1. Choose an invasive species from one of the biomes researched. A few ideas are listed below.
2. Research the following items about your species.

Required Research for your project:

- Image of the Invasive Species
- Common name and Scientific Name (*Genus species*)
- Identify your species as Plant or Animal.
- Identify your species as an Aquatic or Terrestrial Pest.
- Give a physical description of your species (size, color, etc.)
- Where is your species native to (i.e. Where is it from)? (Countries or Continents)
- Why is it a threat or problem in the United States? What are its 'crimes?'
- Where does it occur in the United States? A map would be great!
- How does it spread?
- How did it get to the United States?
- What are some ways its population might be controlled?

Now create a "Most Wanted Flyer" or a Public Service Announcement (like the anti-smoking commercials) with these requirements in mind:

- Your image should be front and center and clearly visible (no poor quality images)
- You should have a clear "WANTED" statement.
- Your required items should be presented clearly, along with a reference for where you found the bulk of your information.
- The layout of the flyer should be eye-catching, yet legible and understandable.
- The video quality of your PSA should be interesting, fit the timeframe of 1 minute, and understandable

Possible Invasive Species (pick one)

Atlantic Cordgrass
French or Scotch Broom
Pampas Grass
Yellow star thistle
Japanese wireweed
Mitten crabs
Green crabs
Striped barnacle
Asian overbite clam
Eastern mud snail
Spotted Goby
Glassy-winged sharpshooter
European Starling
Red Fox
Chinese Tallow Tree
Japanese climbing fern
Lionfish

Possible Endangered Species

Green/loggerhead/leatherback Sea Turtle
Pitcher plants
Gopher Tortoise
Orangutan
Lowland Gorilla
Bluefin Tuna
Asian/Indian/Savanna Elephant
North Atlantic Right Whale
Polar Bear
Arctic Fox

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